Bruguiera hainesii C.G.Rogers (Rhizophoraceae), an endangered species recently discovered in Australia

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Summary

Cooper, W.E., Kudo, H. & Duke, N.C. (2016). *Bruguiera hainesii* C.G.Rogers (Rhizophoraceae), an endangered species recently discovered in Australia. ***Austrobaileya* 9(4): 481–488.** The critically endangered *Bruguiera hainesii* C.G.Rogers (Rhizophoraceae) is newly recorded as occurring on the Australian mainland in north Queensland within the city limits of Cairns. The species is described with notes provided on typification, phenology, distribution, habitat, population structure and conservation status. In addition, another *Bruguiera* species, *B. cylindrica* (L.) Blume, known previously in Queensland from south to Cooktown, is reported with a notable range extension south to Cairns. A revised identification key to all taxa of *Bruguiera* in Australia is presented, along with a table of comparative diagnostic characters.

Key Words: Rhizophoraceae, *Bruguiera*, *Bruguiera hainesii*, *Bruguiera cylindrica,* taxonomy, Australia flora, Queensland flora, identification key

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Introduction

The discovery and occurrence of *Bruguiera hainesii* C.G.Rogers in Australia is documented in this paper. *Bruguiera* Lam., from the small pantropic family Rhizophoraceae is distributed from the Indian subcontinent through Malesia to tropical Australia and islands in the western Pacific (Ding Hou 1957, 1958). The family consists of 16 genera and around 120 species of trees and shrubs worldwide. Four genera, comprising *Rhizophora* L., *Ceriops* Arn., *Kandelia* (DC.) Wight & Arn. and *Bruguiera*, are found exclusively in mangroves (Tomlinson 1994; Duke 2013, 2014), and all are conspicuously viviparous.

Bruguiera is distinguished by calyces with 8–16 lanceolate lobes, 16–32 stamens, explosive pollen release, and distinctly viviparous propagules emergent directly from swollen calyces, instead of from a visible fruiting body (Ding Hou 1957, 1958; Sheue *et al.* 2005; Duke 2013, 2014). The genus consists of two groupings of species (**Table 1**), including: four species with large, mostly solitary flowers, namely *B. exaristata* Ding Hou, *B. gymnorhiza* (L.) Savigny ex Lam. & Poiret, *B.* × *rhynchopetala* (W.C.Ko) X.-J.Ge & N.C.Duke and *B. sexangula* (Lour.) Poir., and three species with 2–5 small flowers in each inflorescence, namely *B. cylindrica* (L.) Blume, *B. hainesii* and *B. parviflora* (Roxb.) Griff. (Duke & Ge 2011). Previous records have shown that six species occurred in Australia (Duke 2006); however, this new discovery confirms that all seven species occur in Australia.

Bruguiera hainesii was discovered in Australia as a population of around 49 trees at Trinity Inlet within the city limits of Cairns by the second author in January 2016. Herbarium collections were made soon after (February 2016) by the first author and taxonomic confirmation was made during a field investigation in early March by the third author. The plants were growing in a

Accepted for publication 28 June 2016

number of patches amongst other commonly occurring mangrove species close by to a busy industrial area.

There were three *Bruguiera* species growing in close proximity to *B. hainesii* in Trinity Inlet, including *B. gymnorhiza*, *B. parviflora* and *B. cylindrica*. The occurrence of *B. cylindrica* is a significant range extension for the species (voucher at BRI: *Cooper et al. WWC2312*) (Kudo 2016) that was previously known for its' southern-most records in the Jeannie River and Endeavour River near Cooktown. A fifth *Bruguiera* species, *Bruguiera exaristata* occurs a few kilometres away, along the Cairns Esplanade. The remaining species in the genus are known to the north of Cairns, in larger riverine estuaries; the most notable being the Daintree River (Duke 2006).

These new discoveries confirm Australia as a region of maximal diversity for *Bruguiera*, having all seven species. The last taxonomic account of the genus in Australia enumerated five species (McClusker 1984), so a revised identification key to all species plus comparative Table of diagnostic features are presented.

Materials and methods

The study is based upon field observations and examination of herbarium material from BRI and CNS. All specimens cited have been seen by the authors. Measurements of the floral parts and fruits are based on fresh material, as well as dry preserved collections.

Taxonomy

Key to *Bruguiera* species in Australia (also see Table 1):

1 Flowers solitary **2**
1. Inflorescence 2–5-flowered, rarely 1 . . . . . **5**

2 Petals without a central spine or spine minute, *c.* 0.2 mm long . . . . . **B. exaristata**
2. Petals with a central spine, > 3 mm long **3**

3 Petals without apical bristles or bristles minute, *c.* 0.3 mm long . . . . . **B. sexangula**
3. Petals with apical bristles, > 1 mm long **4**

4 Petal lobes with 3–4 bristles; bristles > 2 mm long . . . . . **B. gymnorhiza**
4. Petal lobes with 1–2 bristles; bristles < 2 mm long . . . . . **B. × rhynchopetala**

5 Mature flower buds 18–22 mm long, 9–11 calyx lobes . . . . . **B. hainesii**
5. Mature flower buds 10–15 mm long, 8 calyx lobes **6**

6 Calyx lobes stout 2–3 mm long; fruit calyx lobes adpressed against hypocotyl . . . . . **B. parviflora**
6. Calyx lobes elongate 4–6 mm long; fruit calyx lobes reflexed at right angles to the hypocotyl . . . . . **B. cylindrica**

Taxonomy

Bruguiera hainesii C.G.Rogers, *Bull. Misc. Inform. Kew* 1919(5): 225 (1919). **Type:** India (Burma/Myanmar). Mergui, [Panadaung Reserve, 2 January 1919], *C.S. Rogers 456M* (syn: CAL, K *n.v.* [refer to typification section]).

***Illustrations*:** Sheue *et al.* (2005); Duke (2013, 2014).

***Bruguiera hainesii* in Australia: Tree** to 18 m, dbh to 61 cm; evergreen; buttresses well developed, mostly triangular; knee-roots numerous; bark on smaller trees grey with numerous large pustules or lenticels, bark on larger trees dark brown and tessellated. **Stipules** paired, green, curved, 38–42 mm long, glabrous; colleters densely packed, *c.* 0.75 mm long, clustered at base within a triangular or trapezoid pattern about 7.5 × 7.5 mm, *c.* 400 in *c.* 20 rows, viscous. **Leaves**

simple, opposite; petiole 15–33 mm long, channelled adaxially; lamina discolorous, upperside very dark green, underside paler and sometimes sparsely black-dotted, elliptic, oblong-elliptic or elliptic-obovate, coriaceous, 80–140 × 36–61 mm, glabrous, apex acute or very shortly acuminate, base cuneate or attenuate, margin entire and often recurved, venation brochidodromous, intramarginal vein present, primary vein ± flush on upperside and distinctly raised below, secondary veins 9–11 pairs, tertiary venation reticulate. **Inflorescence** axillary, 1–3-flowered (rarely 1), simple dichasium, peduncle 3–8 mm long; bracteoles narrowly triangular or rarely 3-lobed, 0.5–0.8 mm long, silvery, caducous; pedicels 5–7 mm long. **Flowers** bisexual, 22–24 mm long, scentless; **hypanthium** somewhat conical, slightly ribbed, diameter 6–7 mm; sepals free, 8–10, spreading widely at anthesis, yellowish-green, pinkish-green or reddish; **petals** 8–10, free, folded vertically, obovate, 8.5–10 mm long, orange, apex emarginate with a solitary bristle *c.* 4 mm long emerging from the sinus which extends 1–2 mm beyond lobes, lobes each with 3 or 4 apical bristles *c.* 3 mm long, glabrous adaxially or a few minute white hairs near apex, abaxially with long white sericeous hairs near margin; stamens 2 per petal (one usually much longer than the other), 5–8 mm long; anthers linear, 2–2.5 mm long, apex apiculate, bilocular, basifixed or almost so; style slender; stigma 2 or 3-lobed, ovary *c.* 10 mm long, 1 locule with 4 or 6 ovules. **Fruit** seated within hypanthium, sepals ± at right angles and curved at the tips or broadly clawed. **Hypocotyl** emergent from calyx, slightly curved finger-like, slight longitudinal ribbing, green to brownish, up to 120 mm long and 12 mm wide. **Figs. 1–6.**

***Additional specimens examined*: Papua New Guinea:** Port Moresby, Jul/Aug 1918, *White 128* (BRI). **Australia. Queensland.** Cook District: Chinaman Creek, Cairns, Feb 2016, *Cooper 2316, Kudo & Venables* (BRI, CNS); Chinaman Creek, Cairns, Feb 2016, *Cooper 2317, Kudo, Jensen, Jago & Venables* (CNS).

Distribution and habitat: *Bruguiera hainesii* is sparsely distributed through a broad area from South-East Asia (Myanmar) through Malesia (Malaysia, Indonesia, Singapore, Papua New Guinea) to Melanesia (Solomon Islands) and Australia. In Australia, it is known only from a single, small population in Trinity Inlet at Cairns, north Queensland. It occurs in the landward mangrove zone where it is inundated only by very high tides, co-occurring with *Aegiceras corniculatum* (L.) Blanco, *Bruguiera cylindrica*, *B. gymnorhiza* and *Xylocarpus granatum* K.D.Koenig.

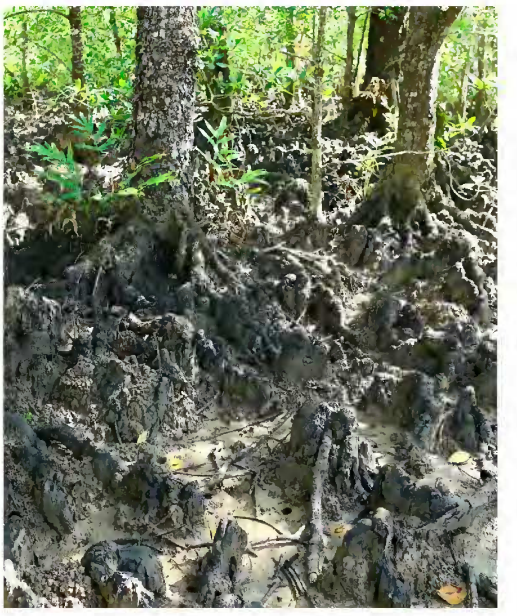

Fig. 1. Growth form habit of ***Bruguiera hainesii*** in Trinity Inlet, Cairns. Note the distinctively erect stems, the rough dark bark, and the stout, knobbly buttresses and surrounding knee roots. Photo: H. Kudo.

***Phenology*:** Flowers have been recorded in January, February and March; mature propagules were observed as scarce in February and March.

***Typification*:** The title page of the paper wherein this species was described has as subtext "Plantarum Novarum in Herbario Horti Regii Conservatarum", which is clear indication that the type collection was at K at least at the time of description. Rogers' herbarium and types are at multiple herbaria, including CAL. There appear to be multiple sheets at K of this collection (K 000732744 and K 000732745 as available online via JSTOR), both collected from Mergui, but neither with

Fig. 2. Stem of adult ***Bruguiera hainesii*** showing detail of the bark (*Cooper 2317 et al.*, CNS). Photo: R.L. Jago.

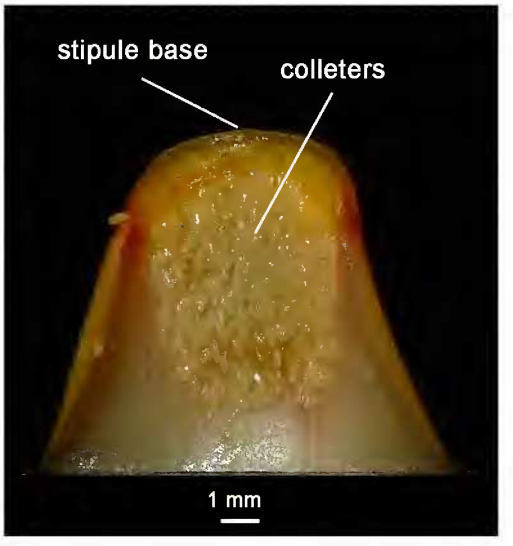

Fig. 3. Distinctive patch of colleters at the inner base of the interpetiolar stipule from a ***Bruguiera hainesii*** apical shoot from the Cairns population. Photo: N.C. Duke.

an indication of collector or date of collection. The online listing of type collections at CAL lists *Rogers 465M* as being extant in that herbarium and the collection may have been distributed elsewhere. Although it is likely that these all represent the Rogers type collection the possibility remains that other material is present at K and elsewhere, so lectotypification of this name is not proposed at this stage (*viz.* McNeill 2014).

***Notes*:** The identification of many mangroves, including species of *Bruguiera* can be difficult where reproductive material is absent. Sheue *et al.* (2005, 2012) suggested using colleters on the stipules to distinguish between similar species of *Bruguiera*. However, we have found that *B. hainesii* is distinct in the field by its growth habit, bark characteristics, flowers and fruit (**Table 1**). Overall, *B. hainesii* is distinguished from other *Bruguiera* by its intermediate sized mature flower buds, on mostly 3-flowered inflorescences, with 8–10 calyx lobes, and bilobed petals with a long spine between lobes and 3 bristles on each tip.

Australian material of *Bruguiera hainesii* differs from those in Singapore (Sheue *et al.* 2005, 2012) in fewer calyx lobes (8 or 9 rarely 10 versus 10 or 11; see **Fig. 4**) and many more colleters (400–500 versus 100–146; see **Fig. 3**).

Genetic evidence indicates that *Bruguiera hainesii* populations from Malaysia and Singapore are a natural hybrid between *B. gymnorhiza* and *B. cylindrica* (Ono *et al.* 2016). If *B. hainesii* is of hybrid origin, then this may explain in part the low numbers of individuals encountered near Cairns when compared to the other co-occurring species. There remain important questions about determinations of hybrid status in *Bruguiera* as the observed stands of *B. hainesii* in Australia have mature viviparous propagules that appear viable (**Fig. 5**). The confirmation of hybrid status for Australian populations of *B. hainesii* requires genetic analysis to determine if this is also the case and whether the same parental species are involved.

Table 1. Diagnostic morphological attributes, including ranges of key measured and multi-state characters, of all *Bruguiera* species in Australia. All measures and observations were taken from fresh material

Component	Attribute*	*B. parviflora*	*B. cylindrica*	*B. hainesii*	*B. exaristata*	*B. gymnorhiza*	*B.* × *rhyn-chopetala*	*B. sexangula*
Leaves	L	70–130	70–170	90–130	50–120	90–240	110–210	100–200
	W	20–40	20–80	40–70	20–50	30–90	40–80	40–70
Mature Flower Buds	Calyx Tube Shape	elongate, slightly ribbed	turbinate, smooth	turbinate, smooth	ribbed	smooth to slightly ribbed	ribbed, sometimes smooth	ribbed, rarely smooth
Inflorescence	Bud N	3–4	3	(1) 2–3	1	1	1	1
	Bud Tip Shape	bluntly acute	bluntly acute	broadly acute	broadly acute	pointed	pointed	pointed
	Bud L	15	10–12	18–22	25–28	30–50	29–40	30–35
	Lobe N	8	8	9–11	8–10	9–15	9–12	12–14
	Lobe L	2–3	4–6	11–12	12–13	15–25	18–21	16–19
	Petal L	1.5–2	3–4	7–9	9–10	13–19	14–17	9–15
	Petal Bristle N	3	2–3	3	0, rarely 1	3–4	1–2	0, rarely 1
	Petal Bristle L	0.3–0.4	0.5–0.6	1.2–1.5	0–0.2	2–3.5	1.2–1.9	0–0.3
	Petal Spine L	0.7–0.8	1–1.2	3–4	0–0.2	5–6	4–5	4–5
	Petal Spine	exceeds lobe	exceeds lobe	exceeds lobe	absent, minute	equal to lobe	equal to lobe	equal to lobe
	Petal Tip Shape	rounded	obtuse	obtuse	obtuse	tending acute	obtuse to acute	obtuse
Mature Fruit	Calyx Lobe Shape	adpressed	fully reflexed	claw-like	claw-like	reflexed slightly	reflexed slightly	reflexed slightly
	Hypocotyl L	90–150	90–150	150–180	90–110	100–250	95–140	50–110
	Hypocotyl W	4–5	5–8	9–11	9–10	15–20	10–20	10–15

*Attribute: N = number; L = length in mm; W = width in mm.

Our observations at Trinity Inlet in April 2016 indicate that there exists a population of *Bruguiera hainesii* with reproducing individuals of different size classes. A preliminary demographic assessment of most, if not all, larger individuals in the population found that of the 49 trees observed, mean stem diameter was 14.3 cm with a range from 2–61 cm (**Fig. 7**). The population structure appeared healthy with abundant younger reproductive individuals and one or two older mast individuals. An indication of the current reproductive potential is shown where the percentage of trees flowering increased from

Fig. 4. Open flower between mature flower buds of a ***Bruguiera hainesii*** inflorescence. Petal lobe bristles and other characters of the flower (note calyx numbers around 9) (*Cooper 2317 et al.*, CNS). Photo: N.C. Duke.

Fig. 5. Face view of open flowers of ***Bruguiera hainesii*** (*Cooper 2317 et al.*, CNS). Photo: R.L. Jago.

Fig. 6. Viviparous mature propagule of ***Bruguiera hainesii***, note the reflexed, claw-like lobes of the calyx (*Cooper 2317 et al.*, CNS). Photo: N.C. Duke.

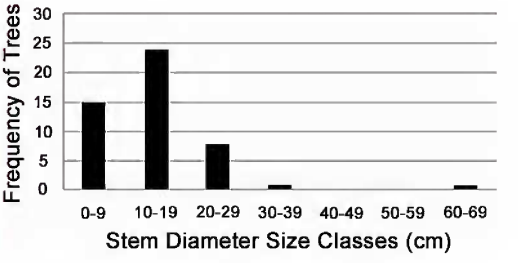

Fig. 7. Population demography of ***Bruguiera hainesii*** in Australia shown for stem diameter size class frequencies. Del: N.C. Duke.

26.7% and 87.5% in the smallest size classes to 100% in all larger size classes (**Fig. 8**). By these preliminary indicators this seemingly isolated population appears viable and sustainable while current circumstances are maintained.

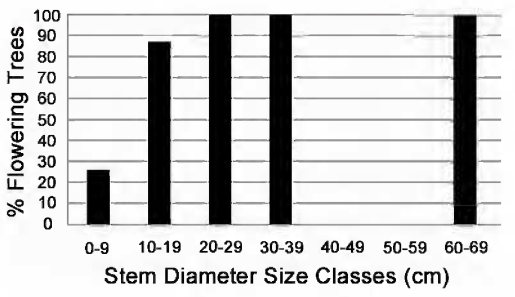

Fig. 8. Age related reproductive condition of ***Bruguiera hainesii*** with stem diameter size class frequencies. Del: N.C. Duke.

***Conservation status*:** *Bruguiera hainesii* is considered by the IUCN to be critically endangered, being known in small numbers from a few seemingly isolated locations in Myanmar, Thailand, Malaysia, Indonesia, Singapore, Papua New Guinea and Solomon Islands. The Solomon Island record refers to an individual tree, only identified in 2011 (Duke *et al.* 2012). Given that the Australian population appears to be viable, more research is needed to determine the reproductive status of the populations in other parts of its distribution range.

It has been estimated that there are less than 250 mature individuals of *Bruguiera hainesii* remaining worldwide (Polidoro *et al.* 2010), although this does not incorporate the Australian population. Given that *B. hainesii* may be a species of hybrid origin (Ono *et al.* 2016) it is possible that some government authorities may view its conservation as being of less significance than the putative parental species. Speciation by hybrid origin is one of the numerous evolutionary pathways whereby many species worldwide have arisen (Hegarty & Hiscock 2004; Mallett 2007), so this origin is not relevant when assessing conservation status, although the IUCN does not assess species considered to be of hybrid origin. The single population and low numbers of individuals in Australia do not greatly augment the world population of this species, so we would support the continued ranking of **Critically Endangered**.

Acknowledgements

The first author thanks Frank Zich and Darren Crayn for support and access to CNS herbarium; Rigel Jensen, Brian Venables and Bob Jago for much appreciated expertise and companionship in the field.

The first author is grateful for permits to collect, which were issued by the then Queensland Department of Environment and Resource Management.

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